Unit 06

ENZYMES

Q.1. Describe metabolism and its types. What is role of enzymes in metabolism?

Ans.

Definition

Metabolism is the set of biochemical reactions that occur in living organisms in order to maintain life.

Explanation of term 'Metabolism'

The term metabolism is derived from a Greek word meaning "change". The concept of metabolism was first of all given by **Ibn-e-Nafees**, who stated that "the body and its parts are always undergoing change"

Importance

These processes allow organisms to grow and reproduce, maintain their structures and respond to their environments. Biochemical reactions in living organisms are essentially energy transfers.

Types

It is of two types

(i) Anabolism

Anabolism includes the biochemical reactions in which larger molecules are synthesized. e.g., Photosynthesis and assimilation. Energy is utilized in anabolism.

Catabolism

Catabolism includes the biochemical reactions in which larger molecules are broken down. e.g., respiration and digestion of food. Energy is released in catabolism

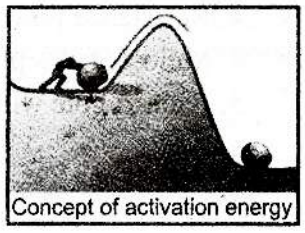
Role of Enzymes during Metabolism

During metabolism, chemicals are transformed from one form to the other by enzymes. Enzymes are crucial to metabolism because they act as biocatalysts and speed up and regulate the metabolic pathways.

Q.2. Define enzymes. Explain enzymatic action.

Ans. Enzymes

Enzymes are proteins that catalyze (i.e. speed up) biochemical reactions and are not changed during the reaction.



Concept of activation energy

Explanation

(i) Substrate

In enzymatic reactions, the molecules at which enzymes act are called substrates.

(ii) Products:

The enzymes convert substrate into different molecules, the products.

(iii) Activation energy:

All chemical reactions require activation energy. It is defined as minimum energy required to start a reaction. The need for activation energy acts as a barrier to the beginning of reaction (as symbolized in the diagram). Enzymes lower such barriers by decreasing the requirement of activation energy. Thus, in the presence of enzymes, reactions proceed at a faster rate.

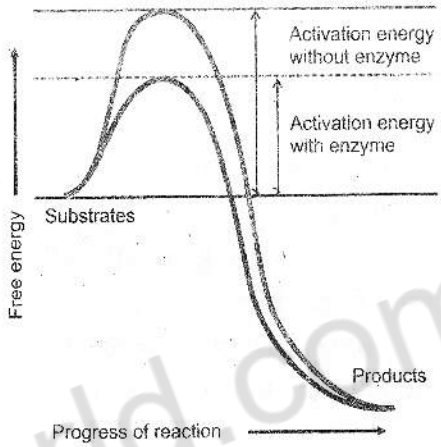


Figure 6.1: Enzymes lower the activation energy

Ways of lowering activation energy

Enzymes lower the activation energy in several ways. They do so by;

(i) Altering the shape of the substrate and reducing the requirement of energy for this change.

(ii) Disrupting the charge distribution on substrates

(iii) Bringing substrates in the correct orientation to react.

Q.3. Describe characteristics of Enzymes.

Ans. Introduction

In 1878, German physiologist Winhelm Kuhne first used the term enzyme. Enzymes are globular proteins and are made of long, linear chains of amino acids that fold to produce a three dimensional molecule.

Characteristics of Enzymes in nature

(i) All enzymes are protein

Almost all enzymes are proteins i.e. they are made of amino acids.

(ii) Increase the rate of reaction

The most enzymes reaction rates are millions of times faster than those of comparable uncatalysed reactions.

(iii) Not consumed by reaction

As with all catalysts, enzymes are not consumed by the reactions they catalyze.

(iv) Enzymes are specific

Enzymes are usually very specific for the type of reaction and for the nature of their substrates.

(v) Active sites

Only a small portion of enzyme molecule is directly involved in catalysis. This catalytic region is known as active site. It recognizes and binds substrate, and then carries out the reaction.

(vi) Enzymes activity can be regulated

Enzyme production can be enhanced or diminished by a cell according to needs. Enzyme activity can also be regulated by inhibitors and activators.

(vii) Cofactors

Some enzymes do not need any additional component to work. However, others require non protein molecules or ions called cofactors.

Cofactors can be either inorganic (e.g. metal ions) or organic (e.g. flavin and heme).

a) Prosthetic groups

If organic cofactors are tightly bound to enzyme, they are called prosthetic groups.

b) Co-enzymes

If organic co-factors are loosely attached with enzyme, they are called co-enzymes. Co-enzymes transport chemical groups from one enzyme to another. Some important co-enzymes are vitamins (e.g. riboflavin, thiamine and folic acid).

(viii) Enzymes can work together in a specific order

Several enzymes can work together in a specific order, creating metabolic pathways. In a metabolic pathway, one enzyme takes the product of another enzyme as a substrate. After the reaction, the product is then passed on to the next enzyme.

Uses of enzymes **(Lahore board 2012 G II)**

Enzymes are extensively used in different industries for fast chemical reactions. For example

i) Food Industry

Enzymes that break starch into simple sugars are used in the production of white bread, buns etc.

ii) Brewing industry

Enzymes break starch and proteins. The products are used by yeast for fermentation (to produce alcohol).

iii) Paper Industry **(Lahore board 2012 G I)**

Enzymes break starch to lower its viscosity that aids in making paper.

iv) Biological detergent **(Lahore board 2011 G I) (short question)**

Protease enzymes are used for the removal of protein stains from clothes. Amylase enzymes are used in dish washing to remove resistant starch residues.

Q.4. Describe factors affecting the rate of enzyme action.

Ans. Enzymes are very sensitive to the environment in which they work. The activity of an enzyme is affected by any change in conditions that alters its chemistry and its shape. Some of the factors that can affect the rate of enzyme action are being discussed below:

1. Temperature: **(Lahore board 2011 G I)**

Increase in temperature speeds up the rate of enzyme catalyzed reactions, but only to a point.

Optimum temperature:

Every enzyme works at its maximum rate at a specific temperature called as the optimum temperature for that enzyme. when temperature rises to a certain limit, the heat adds in the activation energy and also provides kinetic energy and so reactions are accelerated.

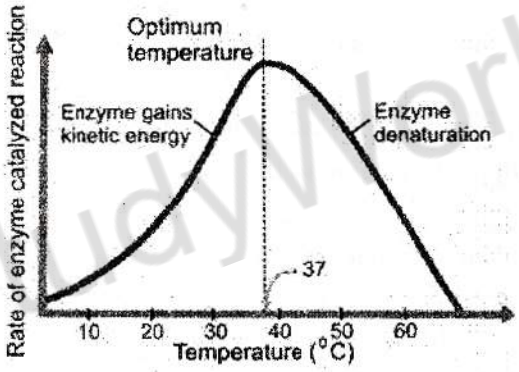


Figure 6.2: Effect of temperature on enzyme activity

Denaturation of enzyme:

When temperature is raised well above the optimum temperature, the heat energy increases the vibrations of atoms of enzyme and the globular structure of enzyme is lost. This is known as denaturation of enzyme.

It results in a rapid decrease in the rate of enzyme action and it may be blocked completely.

2. Substrate Concentration:

If there are enzyme molecules with vacant active sites, an increase in substrate concentration will increase the rate of reaction.

Saturation of active sites:

If the enzyme concentration is kept constant and the amount of substrate is increased, a point is reached where any

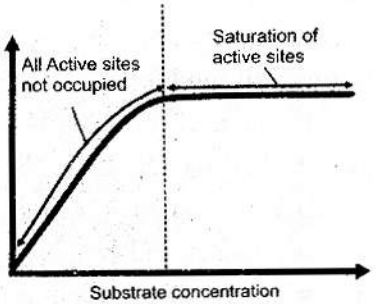


Fig: 6.3 Effect of Substrate on Enzyme Activity

further increase in substrate does not increase the rate of reaction any more. When all the active sites of the enzymes are occupied (at high substrate concentration), any more substrate molecules do not find free active sites. This state is called saturation of active sites and reaction rate does not increase.

3. pH (Optimum pH):

All enzymes work at their maximum rate at a narrow range of pH, called as the optimum pH. A slight change (increase or decrease) in this pH causes retardation in enzyme activity or blocks it completely.

Every enzyme has its specific optimum pH value. For example

Pepsin (working in stomach) is active in acidic medium (low pH).

Trypsin (working in small intestine) shows its activity in alkaline medium (high pH).

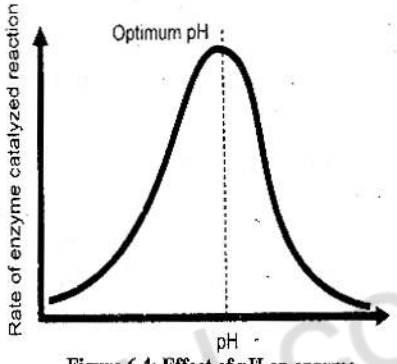


Figure 6.4: Effect of pH on enzyme activity

Change in pH can effect the ionization of the amino acids at the active sites.

Q.5. Describe the mechanism of enzyme action.

Ans. Mechanism of enzyme action $E + S \longrightarrow ES\ Complex \longrightarrow E + P$

When enzyme attachés with the substrate, a temporary enzyme-substrate (ES) complex is formed. The enzyme catalyzes the reaction and substrate is transformed into product. The ES complex breaks enzyme and products are released.

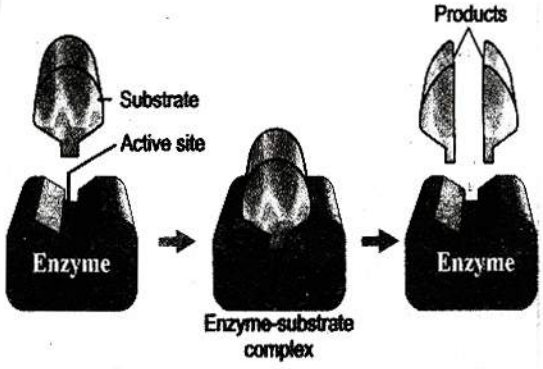


Figure 6.5: Lock and key model of enzyme action

Lock and key model:

In order to explain the mechanism of enzyme action, a German chemist Emil Fischer, in 1894 proposed the lock and key model. According to this model, both enzyme and the substrate possess specific shapes that fit exactly into one another. This model explains enzyme specificity.

Induced fit model:

The induced fit model is more acceptable than the lock & key model. In 1958, an American biologist Daniel Koshland suggested a modification to the lock and key model and proposed the induced fit model. According to this model, active site is not a rigid

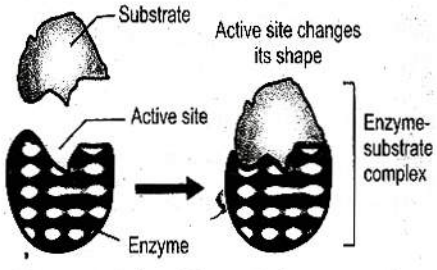


Figure 6.6: Induced fit model of enzyme action

structure rather it is molded into the required shape to perform its function.

Q.6. Describe the specificity of enzymes. **(Lahore board 2012 G I)**

Ans. No. of known enzymes

There are over 2000 known enzymes, each of which is involved in one specific chemical reaction. Enzymes are also substrate specific.

Examples of enzymes specificity

The enzyme protease (which breaks peptide bonds in proteins) will not work on starch (which is broken down by an enzyme amylase). Similarly lipase enzyme acts only on lipids and digests them into fatty acids and glycerol.

Determination of specificity of enzymes

The specificity of different enzymes is determined by the shapes of their active sites. The active sites possess specific geometric shapes that fit with specific substrates. See in fig. 6.7 how the geometric shape of the active site of the given enzyme determines its specificity for substrate
(point out which substrate can exactly fit in the active site).

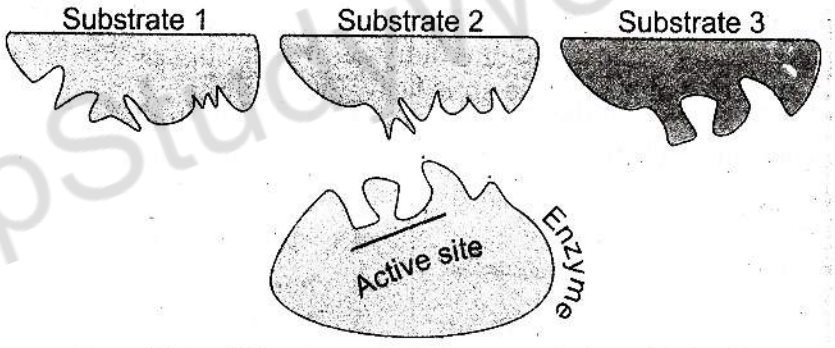


Figure 6.7: Specificity of enzymes due to geometric shape of active site

Multiple Choice Questions

1. What is TRUE about enzymes?
(a) They make biochemical reactions to proceed spontaneously
(b) They lower the activation energy of a reaction
(c) They are not very specific in their choice of substrates
(d) They are needed in large quantities

2. To what category of molecules do enzymes belong?
(a) Carbohydrates (b) Lipids
(c) Nucleic acids (d) Proteins
(Lahore board 2011 G I)

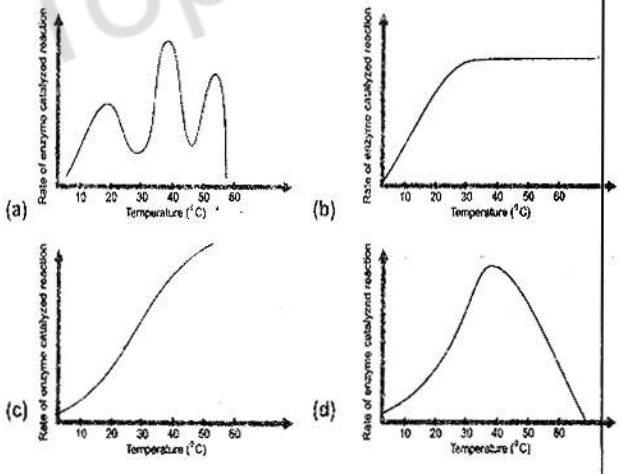
3. What is true about cofactors?
a) Break hydrogen bonds in proteins
b) Help facilitate enzyme activity
c) Increase activation energy

d) Are composed of proteins

4. Prosthetic groups are;
(a) Required by all enzymes
(b) Loosely attached with enzymes
(c) Proteins in nature
(d) Tightly bound to enzyme

5. When we add more substrate to an already occurring enzymatic reaction and there is no increase in the rate of reaction, what would you predict?
(a) All active sites have been occupied by substrate molecules
(b) The enzyme molecules have denatured
(c) More substrate acted as inhibitor
(d) More substrate has disturbed the pH of the medium

6. Which of these graphs correctly shows the effect of temperature on the rate of an enzyme-controlled reaction?



7. The substance on which an enzyme act is called :
(a) Cofactor (b) Inhibitor
(c) Coenzyme (d) Substrate

8. Non- protein part of enzymes are:
(a) Inhibitors (b) Substrate
(c) Cofactors (d) Coenzymes

9. Optimum temperature for enzymes of human body is:
(a) 86°C (b) 37°C
(c) 38°C (d) 39°C

10. Activation energy is required to:
(a) activate enzyme
(b) start a reaction
(c) speed up a reaction (d) None

11. Lock and key Model was proposed by:
(a) Emil Fischer (b) Melcher
(c) Koshland (d) Saugeo

12. Induced Fit model was proposed by:
(a) Emil Fischer (b) Koshaland
(c) Meicher (d) Saqr

13. Which enzyme breaks the peptide bonds:
a) Amylase (b) Protease
(c) Lipase (d) None

14. Which enzyme converts lipids into fattyacid and glycerol?
(a) Lipase (b) Amylase
(c) Pepsin (d) Trypsin

15. Number of discovered enzymes are :
(a) 200 (b) 2000
(c) 3000 (d) 3500

(Lahore board 2011 G II)

Answers					
1.	**b**	6.	**D**	11.	**a**
2.	**d**	7.	**D**	12.	**b**
3.	**b**	8.	**C**	13.	**b**
4.	**d**	9.	**B**	14.	**a**
5.	**a**	10	**B**	15.	**b**

Short Questions

Q:1. Define Activation energy.

Ans. The amount of energy required by all chemical reactions to break chemical bonds and begin the reaction.

Q:2. What are Active sites? **(Lahore board 2011 G II)**

Ans. The small portion of enzyme which take part in a chemical reaction is known as active site.

Q:3. On what substrate Amylase act?

Ans. Amylase is an enzyme which act on starch and convert it into maltose.

Q:4. Define Anabolism. **(Lahore board 2011 G I)**

Ans. Anabolism is the total series of chemical reactions involved in the synthesis of compounds. e.g. Photosynthesis and assimilation.

Q:5. What are Biocatalysts?

Ans. Enzymes are known as biocatalyst because they speed up and regulate the metabolic pathway in living organisms.

Q:6. Define Catabolism. **(Lahore board 2011 G I)**

Ans. Catabolism is the series of chemical reactions in which complex or large molecules are broken down e.g. Respiration and digestion.

Q:7. Define Catalysts.

Ans. These are the chemical substances which speed up a chemical reaction. e.g. Nickel is used as catalyst during hydrogenation of palm oil into banaspati ghee.

Q:8. Define Co-enzymes.

Ans. If organic co-factors are loosely attached with enzyme they are called co-enzymes. Some important vitamins e.g., riboflavin, thiamine and folic acid act as coenzymes.

Q:9. Define Co-factors.

Ans. Some enzymes require non protein molecules or ions to show full activity, these molecules or ions are called cofactors. Cofactors can be either inorganic e.g. metal ions or organic e.g., flavin and heme.

Q:10. What is Denaturation of an enzyme?

Ans. When temperature is raised well above the optimum temperature, the heat energy increases the vibrations of atoms of enzyme molecules and the globular structure of enzyme is lost. This is known as denaturation of enzyme.

Q:11. What is Optimum pH?

Ans. All enzymes work at their maximum rate at a narrow range of pH, called as the optimum pH e.g., pepsin is active in acidic medium (low pH).

Q:12. What is Optimum Temperature?

Ans. Every enzyme works at its maximum rate at a specific temperature called as the optimum temperature for that enzyme e.g., optimum temperature for the maximum working speed of human enzymes is 37°C.

Q:13. Define Enzymes.

Ans. Enzymes are proteins that catalyze (i-e speed up) biochemical reaction and are not changed during the reaction.

Q:14. What is Enzyme Substrate Complex?

Ans. When enzyme attaches with the substrate, a temporary enzyme substrate complex (ES) is formed. The enzyme catalyzes the reaction, substrate is transformed into product, the (ES) complex breaks and enzyme product are released.

Q:15. Define Lipase. Enzyme acts on which components?

Ans. Lipase is the enzyme which acts on lipids and digests them into fatty acids and glycerol.

Q:16. Describe Lock and key model. **(Lahore board 2012 G II)**

Ans. In order to explain the mechanism of enzyme action, a German Chemist Emil Fischer, in 1894 proposed the lock and Key model. According to this model both the enzyme and the substrate possess specific complementary geometric shapes, that fit exactly into one another. This model explains enzyme specificity.

Q:17. Define Metabolism. **(Lahore board 2012 G I)**

Ans. Metabolism is the set of biochemical reactions that occur in living organisms in order to maintain life. It is of two types: Anabolism and Catabolsim.

Q:18. What do you know about the product of the reaction?

Ans. The molecules at which enzymes act are called substrates, and enzymes converts them into different molecules, called products.

Q:19. What do you mean by Saturation of active sites?

Ans. When all the active sites of the enzymes are occupied (at high substrate) any more substrate molecule do not find free active sites, this state is called saturation of active sites and the reactions rate does not increase.

Q:20. What are Substrates?

Ans. In enzymatic reactions, the molecules at the beginning of the process are called substrate.

Q:21. What is Prosthetic Group?

Ans. If organic cofactors are tightly bound to enzyme, they are called prosthetic group.

Q:22. Describe Induced fit model.

Ans. The induced fit model is more acceptable than lock and key model. In 1958, an American biologist Deniel Koshland suggested a modification to the lock and key model and proposed the induced fit model. According to this model the active sites are not rigid structures rather it is molded into the required shape to perform its function.

Q:23. What is optimum temperature for human enzymes?

Ans. The optimum temperature for the maximum working speed of human enzymes is 37°c.

Q:24. How enzymes lower the activation energy?

Ans. Enzymes lower the activation energy in several ways. They do so by;

(i) Altering the shape of the substrates and reducing the amount of energy required to complete the transition.

(ii) Disrupting the charge distribution on substrates.

(iii) Bringing substrates in the correct orientation to react.

Q:25. Define protease?

Ans. Protease is an enzyme which breaks peptide bonds in protein.

Q:26. What is the main use of enzymes in paper industry?

Ans. Enzymes break starch to lower its viscosity that aids in making paper.